PETROGRAPHIC STUDY

By
R. J. COLONY

MONTIZONA COPPER COMPANY

Number 448
Petrographic Report
on a Series of Rock and Ore Specimens
Submitted by
The Montizona Copper Company
Pima County, Arizona

By R. J. COLONY

NEW YORK, FEBRUARY 1925

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PETROGRAPHIC REPORT TO THE MONTIZONA COPPER COMPANY

STATEMENT

A series of samples of rocks and copper ore was submitted for petrographic study. The samples consisted of country rock, dikes cutting the country rock, and copper ore carrying chalcocite partially oxidized to mixed malachite and chrysocolla.

The specimens are samples from the Montizona group of claims. They are numbered as follows:

MONTIZONA GROUP

No. 1. Country rock—a granodiorite.
No. 2. Dike cutting the granodiorite. "Monzonite porphyry."
No. 3. Dike cutting the granodiorite. Gail Borden. "Minette."
No. 4. Dike cutting the granodiorite. The Washington. "Hornblende Andesite."
No. 5. Dike—Aplite core, No. 1 Vein, 700 level.
No. 6. Dike—Aplite core, No. 1 Vein, 700 level, hanging wall.
No. 7. Dike—Aplite—at tunnel level.
No. 8. The ore.

The questions connected with this problem, as formulated in a letter from Mr. Bacon dated January 30, 1925, are as follows:

1. The age of the rocks
2. Possible depth of fracture
3. Effect, if any, of the various dike rocks upon mineralization
4. The possibility that the aplite dikes may be sufficiently mineralized to be considered ore
5. The relation of the aplite and other dike rocks to the ore bodies
6. Origin of the ore

Questions 1 and 2 cannot be answered from petrographic evidence. The other questions can be answered with a reasonable amount of certainty; for this purpose a series of thin sections (13 in all) of the rocks and ore, and polished plates of the ore, were studied petrographically. This report is based on the results of the study. It is illustrated with photomicrographs which show certain important features described in the body of the report. These follow, with detailed descriptions of the individual samples.

PETROGRAPHIC DESCRIPTION

Date February, 1925
Collector Montizona Copper Co. *Field Number* 1 *Description Number* 448

I. FIELD NOTES

Locality: Casa Grande, Pima County, Arizona
Occurrence: Country rock, Granodiorite
Question: Interpretation

II. HAND SPECIMEN DESCRIPTION

General Appearance: Moderately coarse, dark colored crystalline rock

III. MICROSCOPIC STUDY FOR CLASSIFICATION

Texture: Granitoid *Size of Grain:*
Original Structure: Massive poikilitic
Primary Process Represented: Crystallization from magma
Secondary Structure: Slightly fractured; alteration pseudomorphs
Secondary Processes Represented: Slight alteration; fracturing, healing

MINERALOGY (Minerals are grouped for interpretation purposes and are arranged in each group in approximate order of abundance) (In some cases approximate percentages are given)

PRIMARY % (X) Essential Minerals	(Z) SECONDARY % Alteration Products (Especially Intermediate Products)	(M) METAMORPHIC % Recrystallization Minerals	(T) TERTIARY CHANGES OR WEATHERING AND ENRICHMENT EFFECTS (Especially End Products)
Moderately basic plagioclase Alkali feldspars Quartz Biotite	Hornblende Chlorite Epidote Sericite	Not Represented	Essentially very little iron oxide
(Y) Accessory Minerals		(O) INTRODUCED SUBSTANCES OR MINERALIZATION	
Pyroxene Magnetite Titanite Apatite Zircon		Carbonate	

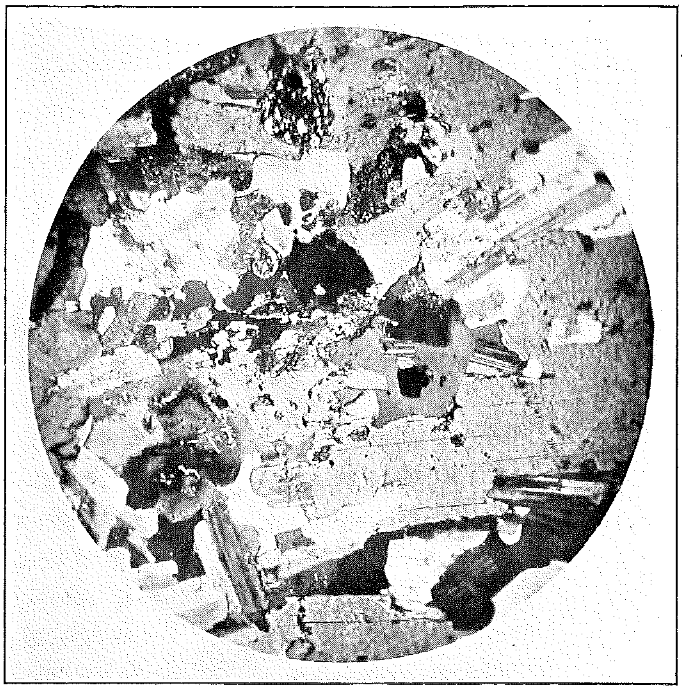
SPECIAL FEATURES:

The feldspars are roughly divided about equally between a moderately basic plagioclase of the composition of andesine, and alkali feldspars including orthoclase and microcline-microperthite. The quartz is end-stage and interstitial; biotite is the dominant ferro-magnesian component, but there is also a little light colored pyroxene, which has been partly converted to secondary hornblende in places. The secondary products are judged to have resulted from the action of the end-stage consolidation residua of the rock itself upon the strictly primary minerals. There is very little modification evident anywhere.

Carbonate has been introduced, probably from the same magmatic source as the rock itself and no doubt related to the very closing stage of the consolidation. There is but little alteration in evidence and but very slight fracturing. There is no objection to the term "granodiorite" as applied to this rock.

ORIGIN OF THE ROCK: Igneous intrusive
CLASSIFICATION: Granodiorite

PETROGRAPHER



Photomicrograph No. 1. Sample No. 1. Taken in polarized light, nicols crossed, magnification 25 diameters, showing the relatively coarse texture and the intermediate mineral makeup of a rock lying between a granite and a quartz diorite. Biotite, plagioclase, orthoclase and quartz all appear in the picture.

There is no objection to the term "granodiorite" as applied to this rock.

PETROGRAPHIC DESCRIPTION

Date February, 1925
Collector Montizona Copper Co. *Field Number* 2 *Description Number* 448

I. FIELD NOTES

Locality: Casa Grande, Pima County, Arizona
Occurrence: Dike. St. Charles No. 1 Claim
Question: Monzonite porphyry (?) Interpretation

II. HAND SPECIMEN DESCRIPTION

General Appearance: Fine textured, grayish slightly porphyritic rock

III. MICROSCOPIC STUDY FOR CLASSIFICATION

Texture: Moderately fine *Size of Grain:*
Original Structure: Slightly porphyritic
Primary Process Represented: Crystallization from magma
Secondary Structure: Very slight. Alteration pseudomorphic
Secondary Processes Represented: Slight alteration

MINERALOGY (Minerals are grouped for interpretation purposes and are arranged in each group in approximate order of abundance)
(In some cases approximate percentages are given)

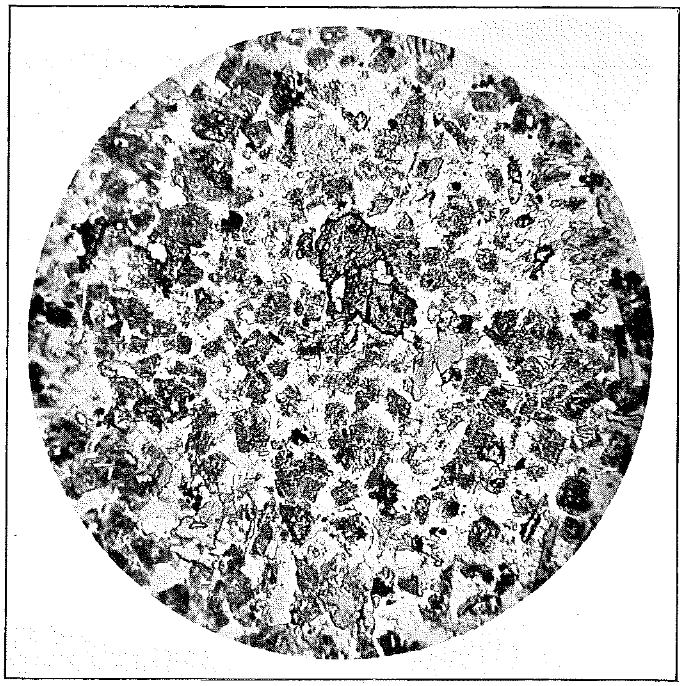
PRIMARY % (X) Essential Minerals	(Z) SECONDARY % Alteration Products (Especially Intermediate Products)	(M) METAMORPHIC % Recrystallization Minerals	(T) TERTIARY CHANGES OR WEATHERING AND ENRICHMENT EFFECTS (Especially End Products)
Alkali feldspars	Epidote Chlorite Sericite	Not Represented	Traces of Iron oxide
(Y) Accessory Minerals		**(O) INTRODUCED SUBSTANCES OR MINERALIZATION**	
Quartz Biotite (altered) Magnetite		Not Represented	

SPECIAL FEATURES:

A highly feldspathic rock carrying interstitial quartz as an accessory component, and a little biotite now changed to chlorite. The feldspar is dominantly alkalic; this, with the texture of the rock, its very small ferro-magnesian content and the rather characteristic interstitial distribution of the little quartz that it carries places it in the group of small intrusives of the Bostonite type. The rock is not mineralized nor deformed in any way. There is no evidence that this rock was in any way connected with the mineralization in the area, nor is there any way of determining its geologic age. If, as stated, it occurs as a dike in the granodiorite, it is of course younger than the granodiorite, but how much younger I cannot say. It may be a differentiate of the granodiorite, but even this cannot be stated with any certainty. It is a rock of simple makeup and of simple history.

ORIGIN OF THE ROCK: Igneous intrusive
CLASSIFICATION: Porphyritic Bostonite

PETROGRAPHER



Photomicrograph No. 2. Rock No. 2. The Porphyritic Bostonite. Taken in ordinary light, magnification 35 diameters. Showing the general aspect of the rock. The very clear spaces are quartz. The darker places are feldspars, with a very little biotite and magnetite. Related to the trachytes in composition. Not deformed or mineralized.

PETROGRAPHIC DESCRIPTION

Date February, 1925
Collector Montizona Copper Co. *Field Number* 3 *Description Number* 448

I. FIELD NOTES

Locality: Pima County, Arizona. Gail Borden No. 6
Occurrence: Dike
Question: Minette (?) Interpretation

II. HAND SPECIMEN DESCRIPTION

General Appearance: A red-brown fine textured rock carrying biotite

III. MICROSCOPIC STUDY FOR CLASSIFICATION

Texture: Fine—partly glassy *Size of Grain:*
Original Structure: Flowage—slightly porphyritic
Primary Process Represented: Consolidation from magma
Secondary Structure: Aggregate pseudomorph
Secondary Processes Represented: Slight alteration

MINERALOGY (Minerals are grouped for interpretation purposes and are arranged in each group in approximate order of abundance) (In some cases approximate percentages are given)

PRIMARY % (X) Essential Minerals	(Z) SECONDARY % Alteration Products (Especially Intermediate Products)	(M) METAMORPHIC % Recrystallization Minerals	(T) TERTIARY CHANGES OR WEATHERING AND ENRICHMENT EFFECTS (Especially End Products)
Rock glass Alkali feldspar Biotite Another ferro-magnesium, altered	Carbonate Quartz Leucoxene Magnetite	Not Represented	A little Iron oxide
(Y) Accessory Minerals Magnetite Apatite		(O) INTRODUCED SUBSTANCES OR MINERALIZATION Not Represented	

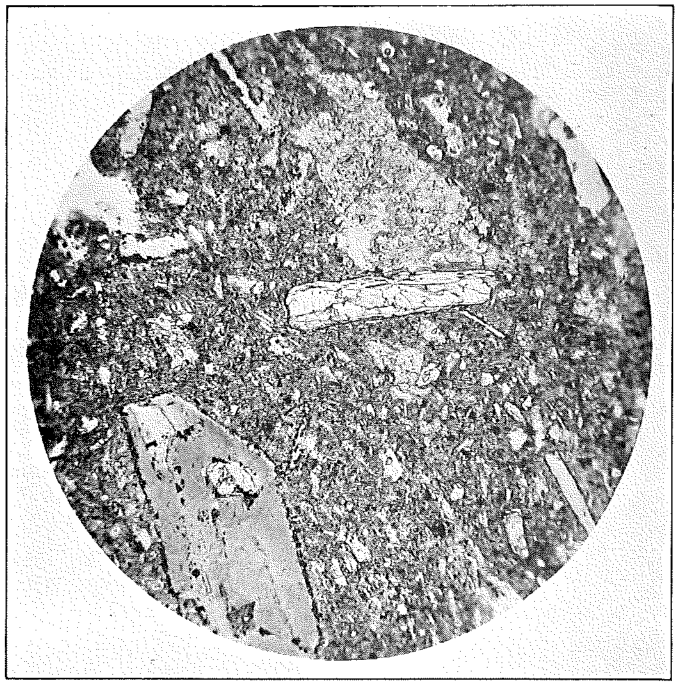
SPECIAL FEATURES:

A very fine textured feldspathic, slightly porphyritic rock with a good flow structure, and containing considerable glass. The feldspars are very minute microscopic laths distributed in the glassy groundmass, which is somewhat oxidized and slightly altered. Little biotite crystals are distributed through the rock and what seems to have been another ferro-magnesian component, appearing as tiny phenocrysts, has been practically wholly carbonated so as to be now made up entirely of aggregate grains of carbonate with sometimes a little quartz, pseudomorphs after some other original, whatever it was (pyroxene or hornblende).

Because of the feldspathic composition, trachytic flow structure and general trachytic aspect, I prefer to think of this rock as more closely related to the trachytes than to the andesites or minettes. It is essentially a porphyritic and glassy (vitrophyric) trachyte, not connected in any way that I can see with the mineralization of the area. I do not know what its geologic age may be. There is no evidence to show that particular feature.

ORIGIN OF THE ROCK: Igneous intrusive
CLASSIFICATION: A vitrophyric mica trachyte

PETROGRAPHER



Photomicrograph No. 3. Rock No. 3. The vitrophyric mica trachyte. Taken in ordinary light, magnification 35 diameters. Showing mica crystal edged with black secondary magnetite (lower left), fine glassy groundmass and flowage structure. Not deformed or mineralized.

PETROGRAPHIC DESCRIPTION

Date February, 1925
Collector Montizona Copper Co. *Field Number* 4 *Description Number* 448

I. FIELD NOTES

Locality: Pima County, Arizona. Washington, No. 5
Occurrence: Dike
Question: Hornblende, andesite (?) Interpretation

II. HAND SPECIMEN DESCRIPTION

General Appearance: A fine-textured, red-grown rock carrying hornblende

III. MICROSCOPIC STUDY FOR CLASSIFICATION

Texture: Felsitic *Size of Grain:*
Original Structure: Porphyritic—trachytic
Primary Process Represented: Consolidation from magma
Secondary Structure: Essentially none
Secondary Processes Represented: Slight alteration

MINERALOGY (Minerals are grouped for interpretation purposes and are arranged in each group in approximate order of abundance)
(In some cases approximate percentages are given)

PRIMARY % (X) Essential Minerals	(Z) SECONDARY % Alteration Products (Especially Intermediate Products)	(M) METAMORPHIC % Recrystallization Minerals	(T) TERTIARY CHANGES OR WEATHERING AND ENRICHMENT EFFECTS (Especially End Products)
Acid plagioclase Orthoclase Hornblende	Very little Sericite Very little Leucoxene	Not Represented	Iron oxide
(Y) Accessory Minerals		**(O) INTRODUCED SUBSTANCES OR MINERALIZATION**	
Magnetite		Not Represented	

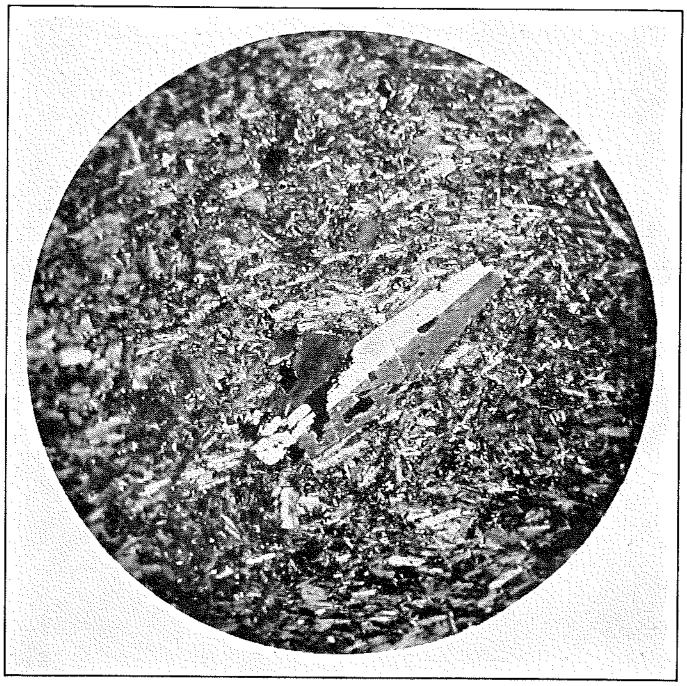
SPECIAL FEATURES:

A strongly feldspathic rock carrying perfectly fresh, unaltered phenocrysts of hornblende distributed in a groundmass made up of alkali feldspar and acid plagioclase with a strong flow (trachytic) structure. The rock is strikingly fresh and free from alteration except for the distribution of red iron oxide in small amount through the groundmass, which possibly may belong to the magmatic stage of the rock instead of having developed through alteration. This rock also has affinities with the trachytes, falling between the trachytes and the andesites.

Trachy-andesite is a good descriptive term to use in connection with it. It has no connection with the mineralization period.

ORIGIN OF THE ROCK: Igneous intrusive
CLASSIFICATION: Hornblende trachy-andesite

PETROGRAPHER



Photomicrograph No. 4. Rock No. 4. The hornblende trachy-andesite. Taken in polarized light, nicols crossed, magnification 25 diameters, showing twinned hornblende crystal (center) and fine groundmass composed largely of little feldspar crystals in flowage arrangement. Not deformed or mineralized.

PETROGRAPHIC DESCRIPTION

Date February, 1925
Collector Montizona Copper Co. *Field Number* 5 *Description Number* 448

I. FIELD NOTES

Locality: Pima County, Arizona. Henry Blair
Occurrence Dike. D. D. core at No. 1 Vein. 700 level
Question: Aplite dike. Interpretation

II. HAND SPECIMEN DESCRIPTION

General Appearance: Light colored, pinkish moderately granitoid rock

III. MICROSCOPIC STUDY FOR CLASSIFICATION

Texture: Moderately granitoid *Size of Grain:*
Original Structure: Massive
Primary Process Represented: Crystallization from magma
Secondary Structure: Slightly fractured
Secondary Processes Represented: Fracturing-healing

MINERALOGY (Minerals are grouped for interpretation purposes and are arranged in each group in approximate order of abundance)
(In some cases approximate percentages are given)

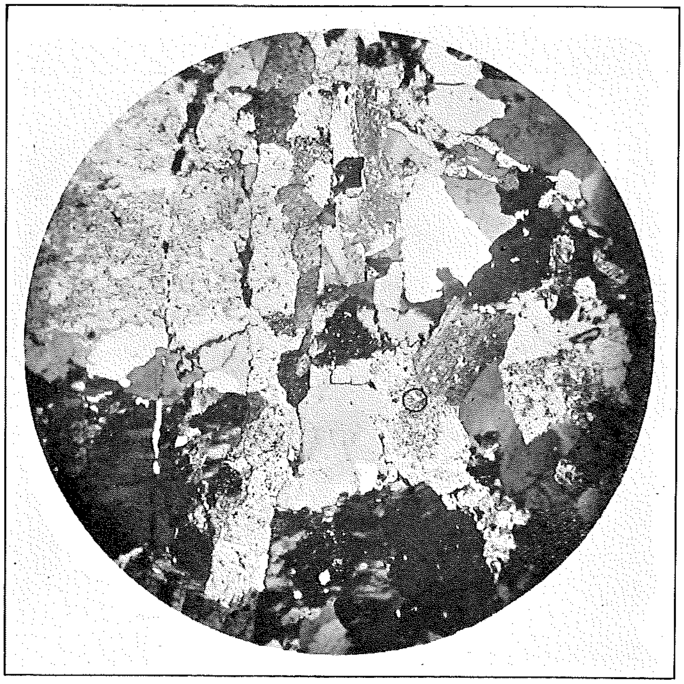
PRIMARY % (X) Essential Minerals	(Z) SECONDARY % Alteration Products (Especially Intermediate Products)	(M) METAMORPHIC % Recrystallization Minerals	(T) TERTIARY CHANGES OR WEATHERING AND ENRICHMENT EFFECTS (Especially End Products)
Alkali feldspars Quartz Muscovite Little acid Plagioclase	Very little Sericite	None	Very little iron oxide
(Y) Accessory Minerals		(O) INTRODUCED SUBSTANCES OR MINERALIZATION	
Very little Biotite Very little Magnetite		Carbonate	

SPECIAL FEATURES:

A simple, acid, moderately granitoid rock consisting largely of microcline, microperthite, orthoclase (all acid alkali feldspars) and quartz, with a little muscovite and very little acid plagioclase. The rock has been slightly fractured and healed with carbonate, but it is not altered, otherwise modified or mineralized. This rock, and the Bostonite, vitrophyric trachyte and trachy-andesite, may be possibly more acid differentiates from the granodiorite. Aside from the tiny little veinlets of carbonate there is no evidence of mineralization, nor is there any proof that this particular rock was in any way connected with the mineralization.

ORIGIN OF THE ROCK: Igneous intrusive
CLASSIFICATION: Aplite

PETROGRAPHER



Photomicrograph No. 5. Rock No. 5. Aplite core. No. 1 Vein, 700 level. Taken in polarized light, nicols crossed, magnification 25 diameters. Quartz (the very light clear areas) feldspars (dusty gray and dark) and very little biotite. Slightly fractured (note the fractures) and healed with carbonate. Not otherwise mineralized.

PETROGRAPHIC DESCRIPTION

Date February, 1925
Collector Montizona Copper Co. *Field Number* 6 *Description Number* 448

I. FIELD NOTES

Locality: Pima County, Arizona. Henry Blair
Occurrence: Dike D. D. core at No. 1 Vein. 700 Level. Hanging Wall.
Question: Aplite dike. Interpretation

II. HAND SPECIMEN DESCRIPTION

General Appearance: Moderately granitoid, pinkish light colored rock

III. MICROSCOPIC STUDY FOR CLASSIFICATION

Texture: Moderately granitoid *Size of Grain:*
Original Structure: Massive, slightly micrographic
Primary Process Represented: Crystallization from magma
Secondary Structure: Brecciated
Secondary Processes Represented: Healing and mineralization

MINERALOGY (Minerals are grouped for interpretation purposes and are arranged in each group in approximate order of abundance) (In some cases approximate percentages are given)

PRIMARY % (X) Essential Minerals	(Z) SECONDARY % Alteration Products (Especially Intermediate Products)	(M) METAMORPHIC % Recrystallization Minerals	(T) TERTIARY CHANGES OR WEATHERING AND ENRICHMENT EFFECTS (Especially End Products)
Alkali feldspars Quartz Muscovite Little acid Plagioclase	Very little Sericite Very little Chlorite	None	Iron oxide a little Malachite
(Y) Accessory Minerals		(O) INTRODUCED SUBSTANCES OR MINERALIZATION Carbonate a Black Metallic Epidote	

SPECIAL FEATURES:

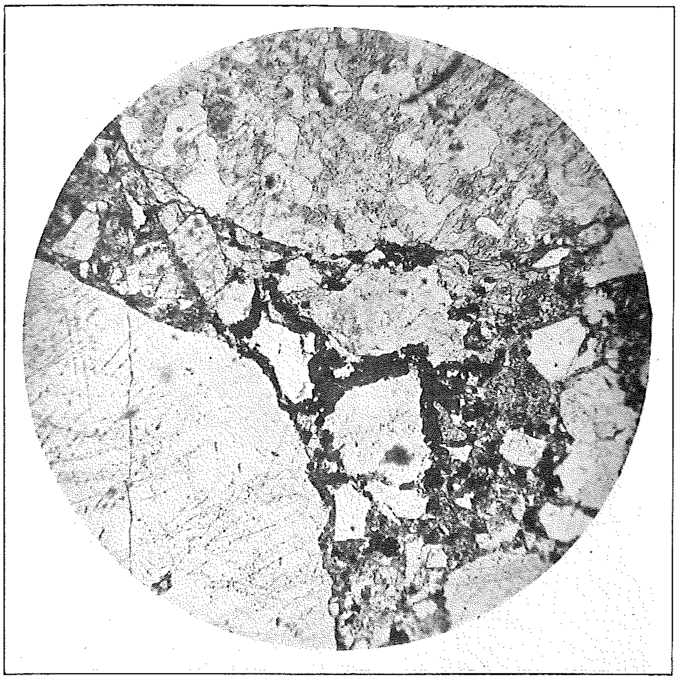
Similar in general mineralogy and character to No. 5, and like it made up of alkali feldspar and quartz. This rock has been brecciated, however, and the crush-zones thus produced have been healed and mineralized with carbonate, epidote, and a black metallic mineral of some sort now extensively oxidized and converted into red iron oxide. Some of the black metallic may possibly be copper bearing, since there is a little malachite associated with it, but how extensive the copper may be I cannot tell.

By "mineralization" I mean the deposition of carbonate, epidote and the black metallic, all judged to be products of hydrothermal action coming from deeper seated sources and probably under igneous control.

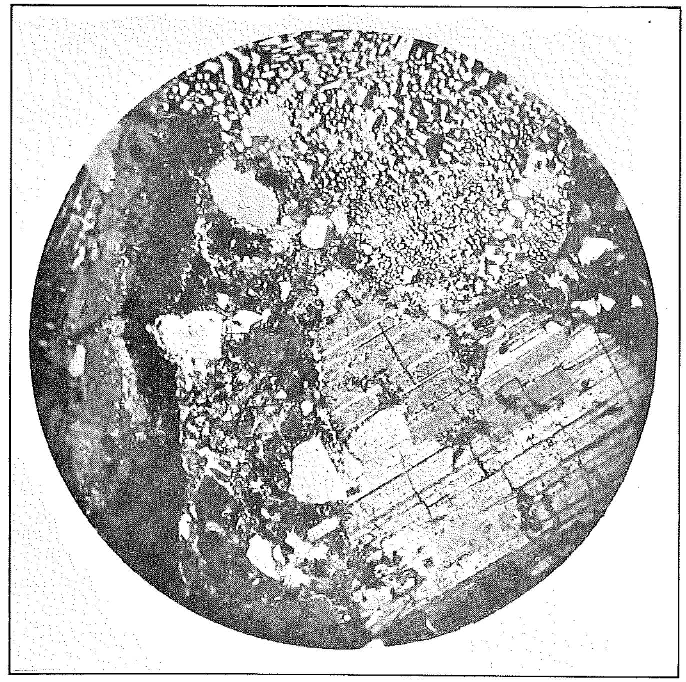
The aplite dike is not itself the source nor the cause of mineralization, since the dike has been affected by the same sets of processes which were responsible for the deposition of the ore, and is therefore earlier than the ore.

ORIGIN OF THE ROCK: Igneous intrusive
CLASSIFICATION: Aplite, brecciated and somewhat mineralized

PETROGRAPHER



Photomicrograph No. 6. Rock No. 6. Aplite core. No. 1 Vein, 700 level, Hanging wall. Taken in ordinary light, magnification 35 diameters. Showing crush-zone in the aplite (brecciated area.) Note the broken condition, and the filling or cementing matter (carbonate, epidote). A little primary copper ore was deposited in places like this, but the ore has been converted to oxidized products like malachite. Where the aplite is brecciated it may be mineralized, but it is not the source of the ore.



Photomicrograph No. 7. Rock No. 6. Aplite core. No. 1 Vein. 700 level Hanging wall. Taken in polarized light, nicols crossed, magnification 25 diameters. Another section, showing quartz-feldspar micrographic intergrowth (top), feldspar crystal (bottom) and brecciated zones at left and right.

PETROGRAPHIC DESCRIPTION

Date February, 1925
Collector Montizona Copper Co. *Field Number* 7 *Description Number* 448

I. FIELD NOTES

Locality: Pima County, Arizona. Henry Blair
Occurrence: Dike, at tunnel level
Question: Aplite dike. Interpretation

II. HAND SPECIMEN DESCRIPTION

General Appearance: Light colored, pinkish, moderately granitoid rock

III. MICROSCOPIC STUDY FOR CLASSIFICATION

Texture: Moderately granitoid *Size of Grain:*
Original Structure: Massive
Primary Process Represented: Crystallization from magma
Secondary Structure: Essentially none
Secondary Processes Represented: Essentially none

MINERALOGY (Minerals are grouped for interpretation purposes and are arranged in each group in approximate order of abundance)
(In some cases approximate percentages are given)

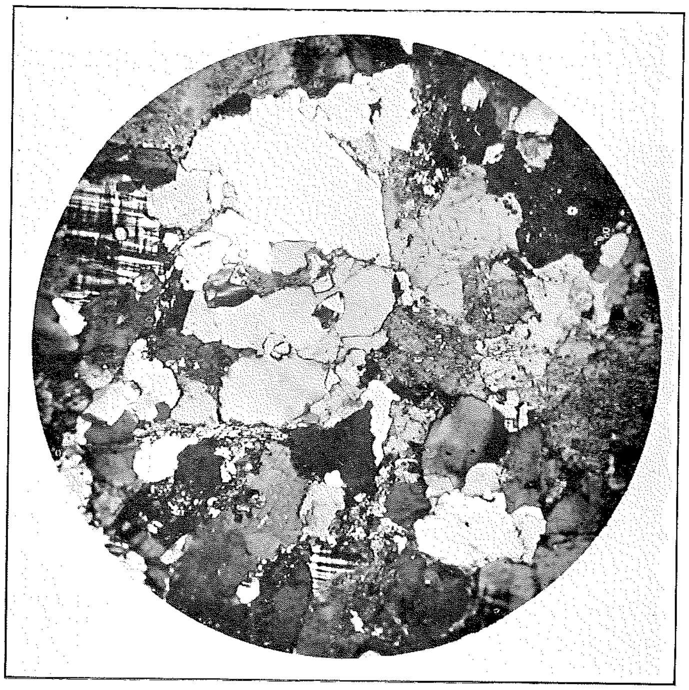
PRIMARY %	(Z) SECONDARY %	(M) METAMORPHIC %	(T) TERTIARY CHANGES OR WEATHERING AND ENRICHMENT EFFECTS (Especially End Products)
(X) Essential Minerals Alkali feldspars Quartz Very little Biotite	Alteration Products (Especially Intermediate Products) Very little: Chlorite, Sericite, Rutile, Leucoxene	Recrystallization Minerals None	Very little Iron oxide
(Y) Accessory Minerals Zircon Magnetite Colorless Epidote		(O) INTRODUCED SUBSTANCES OR MINERALIZATION None	

SPECIAL FEATURES:

Similar to No. 5. Simple in makeup and history. Not brecciated, as is No. 6, and not mineralized. This sample carries biotite instead of muscovite, but otherwise is the same as 5 and 6, made up very largely of alkali feldspars and quartz. The products listed as secondary occur in very small amounts.

ORIGIN OF THE ROCK: Igneous intrusive
CLASSIFICATION: Aplite

PETROGRAPHER



Photomicrograph No. 8. Rock No. 7. Aplite at Tunnel level. Taken in polarized light, nicols crossed, magnification 25 diameters. Showing quartz (light clear areas) and feldspars (darker, dusty and cross-barred areas). Not crushed, not brecciated, not mineralized.

PETROGRAPHIC DESCRIPTION

Date February, 1925
Collector Montizona Copper Co. *Field Number* 8 *Description Number* 448

I. FIELD NOTES

Locality: Pima County, Arizona. Henry Blair
Occurrence: Ore
Question: Interpretation

II. HAND SPECIMEN DESCRIPTION

General Appearance: Quartzose copper ore carrying chalcocite and green oxidation products

III. MICROSCOPIC STUDY FOR CLASSIFICATION

Texture: Coarse, variable *Size of Grain:*
Original Structure: Massive crystalline
Primary Process Represented: Deposition of vein-matter
Secondary Structure: Strongly brecciated and healed
Secondary Processes Represented: Brecciation, mineralization, oxidation

MINERALOGY (Minerals are grouped for interpretation purposes and are arranged in each group in approximate order of abundance)
(In some cases approximate percentages are given)

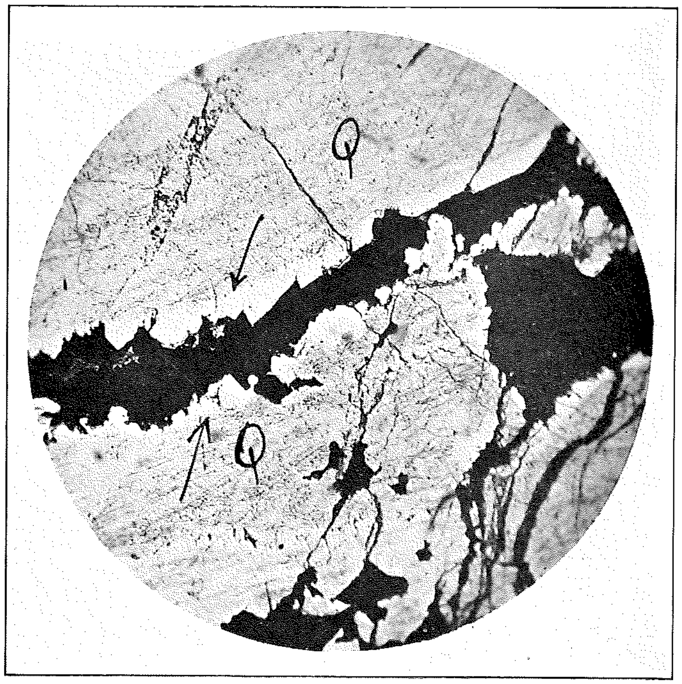
PRIMARY % (X) Essential Minerals	(Z) SECONDARY % Alteration Products (Especially Intermediate Products)	(M) METAMORPHIC % Recrystallization Minerals	(T) TERTIARY CHANGES OR WEATHERING AND ENRICHMENT EFFECTS (Especially End Products)
Obscure	Obscure or Absent	Not Represented	Chalcocite Cuprite (little) Malachite Chrysocolla Azurite (little) Iron oxide Covellite
(Y) Accessory Minerals		(O) INTRODUCED SUBSTANCES OR MINERALIZATION	
Obscure		Quartz Pyrite A copper mineral of some sort now destroyed	

SPECIAL FEATURES:

(For Special Features see page 24)

ORIGIN OF THE ROCK: Hypogene and Supergene
CLASSIFICATION: Enriched and partly oxidized copper ore

PETROGRAPHER

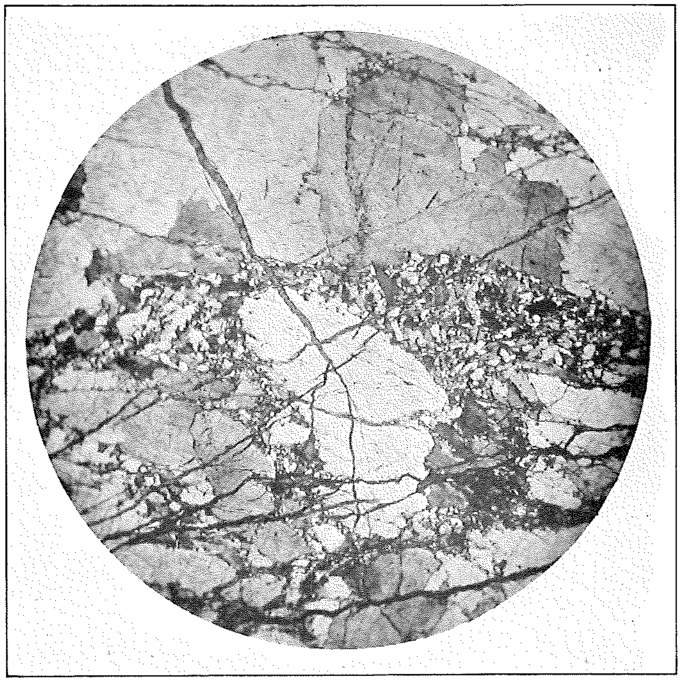


Photomicrograph No. 9. The ore (No. 8). Montizona claims. Taken in ordinary light, magnification 35 diameters. Showing the following features:

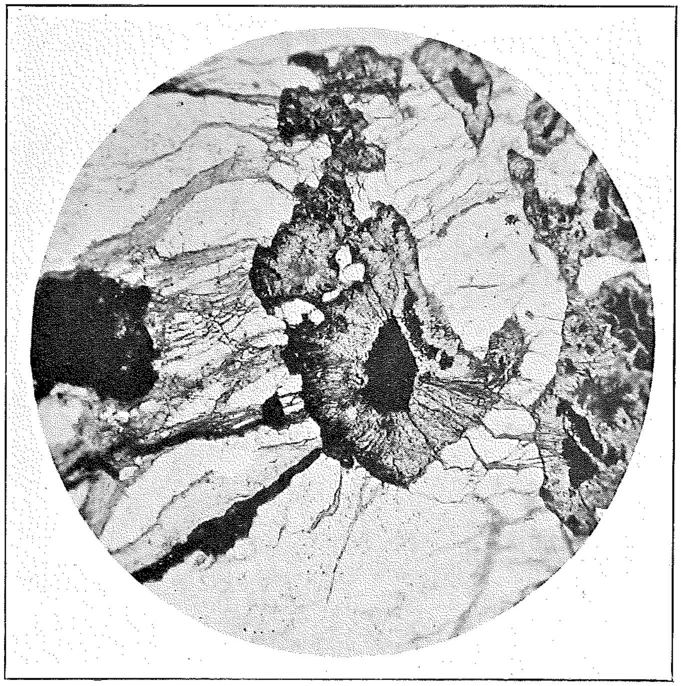
1. The earlier vein quartz (Q).

2. Fractured zones in the earlier vein quartz, healed with additional *clear* quartz, carrying ore minerals (arrow). First period of deformation *of the vein quartz.*

3. Later fractures cutting vein quartz and also the *later* veinlets in the vein. These filled with oxidation products of the chalcocite. All the ore minerals look black in this light.



Photomicrograph No. 10. The ore (No. 8). Montizona claims. Taken in polarized light, nicols crossed, magnification 25 diameters. Showing a crush-zone in the earlier vein quartz, and still later fractures cutting the older vein quartz and the later quartz of the crush-zone. These very late fractures are filled with oxidation products derived from the chalcocite.

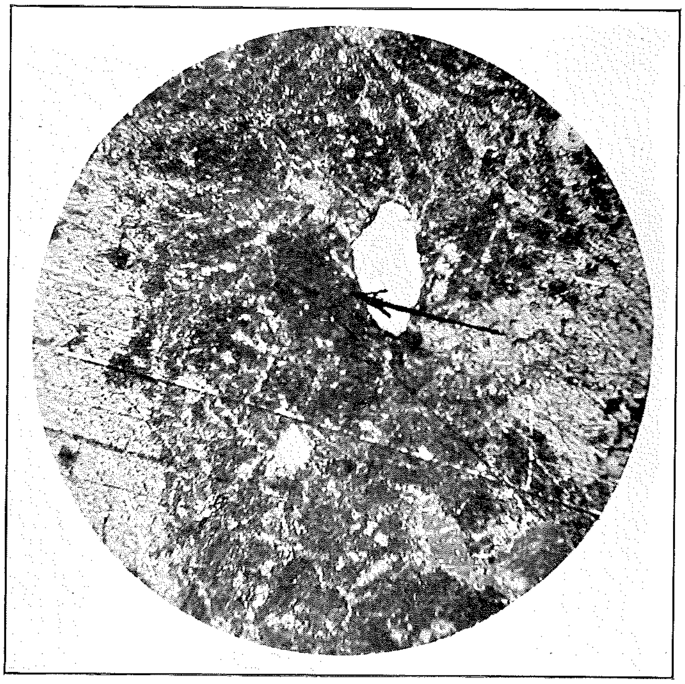


Photomicrograph No. 11. The ore (No. 8). Montizona claims. Taken in ordinary light, magnification 35 diameters, showing, very beautifully, the following features:

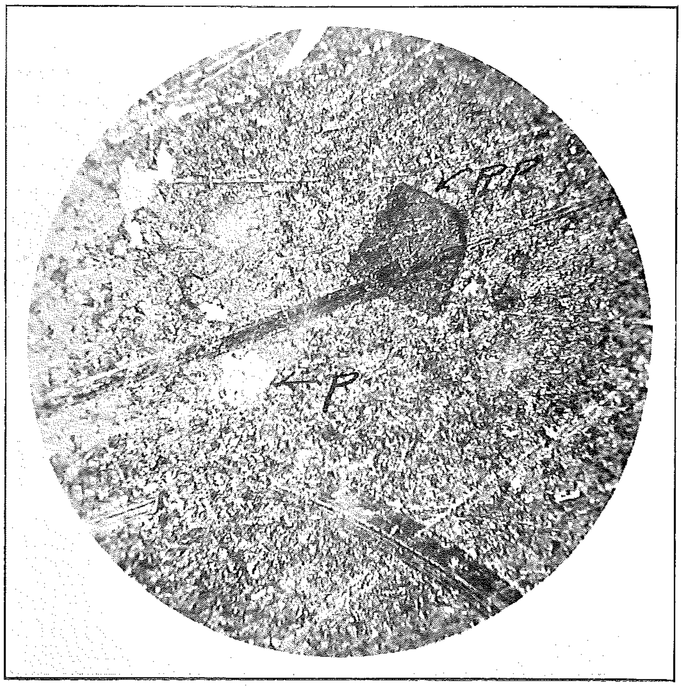
1. Vein quartz of the early stage.

2. Cores or unoxidized remnants of chalcocite (black) surrounded by malachite and chrysocolla (dark gray).

3. Late (younger) veinlets, connected with the areas occupied by the chalcocite and filled with the oxidation products of it.



Photomicrograph No. 12. The ore (No. 8). Montizona claims. Taken in *oblique reflected* light from thin section, magnification 65 diameters. The two very light colored (white) spots are holes in the section. The light is *reflected* from the glass in this case. It does not come through from below. The entire field is black *chalcocite,* showing grinding scratches (straight lines). The irregular *very* black areas are "ghosts," or structural remnants of an older original and primary mineral replaced by the chalcocite. The dense black spot (arrow) is red ruby copper oxide (cuprite). These conditions in the chalcocite lead me to believe that it is secondary (supergene) in origin.



Photomicrograph No. 13. The ore (No. 8). Montizona claims. Taken in *oblique reflected* light from a thin section, magnification 65 diameters. The whole field is chalcocite (note grinding scratches). A totally replaced pyrite crystal (RP), a "ghost" or replacement structure, now only faintly outlined by iron oxide, is shown, and another fresh and still unreplaced primary pyrite crystal (P) in good crystal form lies nearby. Note that the chalcocite structure passes *through* the replacement ghost (RP) of pyrite.

Special Features

FIELD NUMBER 8

The gangue matter of the ore is quartz. There is evidence of at least two periods of deformation and of primary mineralization, followed by replacement of the primary ore minerals through supergene processes, and of the oxidation of the secondary sulphide ore mineral to carbonate, oxide and silicate of copper and to oxide of iron. The history of the ore and mineralization sequence in brief is as follows:

1. Filling and probable replacement in part of a crush-zone in the granodiorite with quartz of vein type and hypogene origin, probably under magmatic control. During the earlier stages of this vein-making process the quartz was either not connected with ore minerals at all, or else they were in part precipitated at the very closing stages of vein formation.

2. At the close of the vein-making time, when the quartz had almost entirely crystallized, renewed stress deformed the already-formed quartz vein, fracturing, straining and crushing the quartz and opening up channels for the ore-mineralization which followed.

3. Additional quartz, associated with ore minerals, was precipitated, the solutions taking advantage of the weaknesses produced by the deformation spoken of, which is shown very beautifully in the thin sections. The ore minerals were pyrite certainly, and in addition a copper bearing mineral of some sort, possibly like bornite, or chalcopyrite, though there is no record left as to the exact character of the original copper mineral. It has been wholly destroyed and replaced with secondary chalcocite.

That the original copper bearing mineral has been replaced is proved by ''ghosts'' or remnants of former structures, shown in numerous places in the chalcocite. That the chalcocite is secondary and supergene in origin is proved by the very presence of inherited structures (''ghosts'') and by the fact that ruby copper oxide (cuprite) is intimately mixed with the chalcocite.

4. Subsequent to the enrichment of the primary copper-bearing mineral with supergene chalcocite, a second period of deformation of sufficient intensity to fracture the mineralized zone ensued, and through these later channels solutions circulated, fed in part by the slowly oxidizing chalcocite. In such places the oxidation products have precipitated, and oxidation has extended through them to the chalcocite itself so that much of it has been converted to the green carbonate (malachite) and silicate (chrysocolla), and more or less iron oxide has formed.

A little primary and still unreplaced pyrite exists, and likewise remnants of replaced pyrite. Wherever pyrite occurs, however, it shows good crystal form, quite unlike the irregular patches of chalcocite which is judged to have inherited the form and distribution it has from some other original mineral *unlike* pyrite, and copper-bearing in the first place.

Since the chalcocite is judged to be hypogene in origin, it should extend in depth to the old water table level that existed at the time the chalcocite was being formed, whatever that may have been; and below that level the original primary ore should be encountered, provided the deposit behaves in the normal and expectable way. I do not know what the original was, but, judging from present replacement features, it was a copper-bearing mineral of some sort.

A little covellite is distributed very sparingly through the chalcocite, itself a later product and of secondary origin like the chalcocite.

General Summary

THE MONTIZONA GROUP

The dike rocks of this group consist of:

(a) *Porphyritic Bostonite (No. 2),* provisionally called "Monzonite porphyry" from the hand specimen.

(b) *Vitrophyric Mica trachyte (No.3),* provisionally called "Minette" in the hand specimen.

(c) *Hornblende Trachy-andesite (No. 4),* provisionally called "Hornblende andesite" in the hand specimen.

These dikes cut the country rock, a granodiorite (No. 1); they are not mineralized nor do they exhibit any deformation at all. So far as can be told they are not related to the ore, nor are they responsible for the mineralization. I cannot tell whether they are earlier than, or later than, the ore; there is no evidence to show this. They are of course later than the granodiorite, and may be differentiates of the magma that produced it. They are a little more acid than the granodiorite, and in composition are very closely related to the trachytes. I cannot see that they have any direct connection with the ore at all. In addition to these dikes there is the aplite (d). Samples from three different places are included in the series.

No. 7. *Aplite at tunnel level.* This is simple in history and in composition. It is not fractured nor deformed in any way, nor is it mineralized, and so far as the evidence goes, it has no connection with the ore at all.

No. 6. *Aplite at No. 1 Vein, Hanging Wall.* This rock has been affected by the same dynamic conditions responsible for the production of the shear zones which were subsequently mineralized and now form the veins. The aplite here has been brecciated to some degree, and these broken places have been healed with epidote and carbonate of hydrothermal origin, and a little black metallic resembling specularite (iron oxide). In addition some copper mineral was introduced which, judging from the small sample submitted, seems to have been wholly converted into malachite.

From the evidence presented by this specimen, in connection with Nos. 5 and 6, which are neither brecciated nor mineralized, I judge that the aplite dike was not the source of the mineralization, nor was it responsible for the ore at all. I judge the ore is later than the aplite, for the aplite is mineralized only where it was brecciated, affording in such places channels of access for the ore-bearing solutions. The only influence exerted by the aplite was to direct in places the direction of the shearing so that zones were opened paralleling the dike, in a general way; where such shear zones are close to the aplite, the aplite itself is brecciated and mineralized to some extent.

No. 5. *Aplite. At No. 1 Vein, 700 level.* This, like No. 7, is simple in history and make-up. There are a few minute fractures, healed with carbonate, but the rock has not been brecciated or otherwise mineralized.

None of the dike rocks is responsible for mineralization nor is any one of them the source of mineralization. It is possible that wherever the aplite is brecciated and next to, or a part of, a shear zone which has been mineralized, it might serve as an ore, but it is not an ore of itself.

The *granodiorite,* No. 1, is a simple granitoid massive crystalline rock intermediate between a granite and a quartz diorite, and it may therefore be classified as a granodiorite. There are no special features connected with it.

The ore (No. 8). Judging from the samples submitted the ore consists entirely of quartz vein matter which was introduced into and which has largely replaced a shear zone. A primary copper bearing mineral of some sort, and a little pyrite, were associated with the quartz as original ore minerals. The original copper mineral has been wholly replaced with secondary chalcocite and ruby copper (copper oxide or cuprite), and most of the pyrite has likewise been destroyed. Moreover, the secondary chalcocite has been partially oxidized in place and converted to malachite and chrysocolla. The sequence of dynamic events represented in the ore samples is as follows:

1. Mineralization of a shear zone ("fissure") with vein quartz, probably under magmatic control.

2. Toward the end of the quartz deposition some of the ore minerals began to form.

3. Renewed stress, which crushed and fractured the quartz vein matter, just deposited.

4. Continued deposition of quartz, with which was associated the primary copper ore mineral and pyrite. In this connection it was noted that:

    (a) Wherever pyrite is seen, it has the characteristic pyrite form;

    (b) The original copper mineral was without crystal form, occurring in shapeless patches and blotches, just as bornite and chalcopyrite usually do. It is possible, therefore, that the original may have been either bornite or chalcopyrite, or both, but there is no proof of this.

    (c) Whatever the original was, it has been wholly replaced by supergene processes, with chalcocite, leaving only "ghosts" or remnants of original structures within the chalcocite. This fact, together with the occurrence of ruby copper (cuprite) mixed with chalcocite leads me to interpret the chalcocite as secondary, pseudomorphous after some former original.

5. Renewed (third stage) stress, that fractured the older quartz vein matter, cut across the *earlier* fractures, and opened up channels of access to meteoric waters and oxidizing influences. The secondary chalcocite itself is undergoing modification and changing in place to cuprite, covellite, malachite and chrysocolla. Of these oxidation products the most abundant are malachite and chrysocolla.

When the original water table level that existed when the supergene processes were in operation is finally reached, the primary copper mineral should be encountered at the bottom of the zone of enrichment.

R. J. Colony,
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